OBSERVATIONS ON POPULATION BIOLOGY OF THE BLACKMOUTH CATSHARK *GALEUS MELASTOMUS* (CHONDRICHTHYES, SCYLIORHINIDAE) IN THE IONIAN SEA

by

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ABSTRACT. - Some aspects of *Galeus melastomus* population biology in the Ionian Sea (Mediterranean Sea) are reported. Data were collected during seven trawl surveys carried out from 1985 to 1989. Results relative to pattern of distribution with regard to depth, time, structure of population and reproduction are discussed. *Galeus melastomus* is found exclusively in the bathyal depths and its population is mostly made up of young individuals. Reproduction occurs continuously throughout the year and it is mainly realized at the lowest depths at which the species is found.

RÉSUMÉ. - Les auteurs analysent quelques aspects de la biologie de la population de *Galeus melastomus* vivant dans la Mer Ionienne (Mer Méditerranée). Les données ont été relevées au cours de sept campagnes expérimentales de chalutage effectuées de 1985 à 1989. Les résultats obtenus concernent la distribution bathymétrique, la structure de la population et la reproduction. *Galeus melastomus* a été trouvé uniquement au niveau bathyal et sa population est constituée surtout de jeunes individus. La reproduction a lieu pendant toute l'année et elle se réalise aux plus faibles profondeurs auxquelles l'espèce a été trouvée.

Key-words. - Scyliorhinidae, *Galeus melastomus*, MED, Ionian Sea, Depth distribution, Population structure.

The blackmouth catshark *Galeus melastomus* Rafinesque, 1810 is found in all parts of the North-Eastern Atlantic Ocean, from the Scandinavian coast to that of Senegal as well as throughout the Mediterranean Sea (Compagno, 1984). In some parts of these areas it is caught as a by-catch of trawl fishing at bathyal depths. Its abundance, in terms of both numbers and biomass (with no comparison made in economic terms as its commercial value is relatively low) gives the species a particular importance from the point of view of the marine ecosystem.

The biology of *Galeus melastomus* on the Tunisian coasts is known owing to the works of Capapé and Zaouali (1976, 1977) and Capapé and Ben Brahim (1984). Recent information on the species within Italian seas has been reported by Relini Orsi *et al.* (1982).

However knowledge of the biology of this shark in the Ionian Sea is limited (Tursi *et al.*, 1990). For this reason, aspects regarding the space-time distribution of individuals, the structure of the population and its reproduction, are examined in this paper.

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MATERIALS AND METHODS

The area investigated is situated between the Cape of Otranto (Lecce) and the Spartivento Cape (Reggio Calabria) to a depth of 650 m; it is about 3,238 square miles in area (Fig. 1).

The trawl surveys took place in the following periods: 1) April-May 1985; 2) September-October 1985; 3) April-May 1986; 4) September-October 1986; 5) April-May 1987; 6) October-November 1988; 7) June 1989. Additional specimens were taken during some samplings carried out in February, March and August 1986.

A professional 57 t gross tonnage motor-powered fishing boat, with a 220 Hp engine, was used. It was equipped with nylon otter-trawl nets with 480 meshes of 24 mm at the mouth and 240 meshes of 16 mm at the cod-end.

The experimental sampling methodology adopted, for biological and statistical reasons (Fogarty, 1985), was random-stratified, for which the area examined was subdivided into 5 depth strata: I = 0-50 m; II = 50-100 m; III = 100-200 m; IV = 200-400 m; V = 400-650 m.

Casting the net for the fishing, which was carried out from dawn to sunset, took 1 hour. The catches were weighed on board and the number of individuals was counted. The catches for each fishing survey, expressed in number/hour, were taken as indicative of the abundance of the population of *Galeus melastomus* in the area.

The following parameters were recorded in the laboratory, for each individual of *Galeus melastomus*: total weight, total length, sex and stage of maturity of the gonads, in accordance with Holden and Raitt (1974). In particular the maturity of males can be easily and best defined from the state of development of the mixopterygia. These of

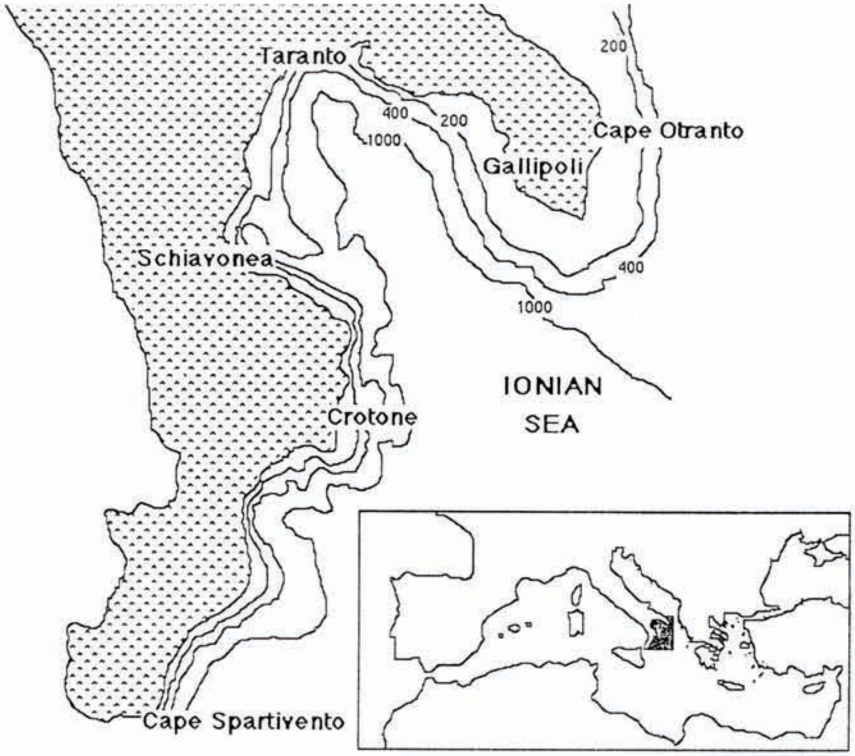

Fig. 1. - Map of the investigated area.

immature individual are small and flacoid and do not reach the posterior edge of the pelvic fin. In maturing individual the mixopterygia are larger; they extend to the posterior edge of the pelvic fins and the internal instructure is visible but soft and not ossified; in mature individual the mixopterygia extend well beyond the posterior edge of the pelvic fin, the internal structure is visible and is hard and ossified.

Maturity of females must be determined by internal examination. The reproductive system of females consists of ovaries, shell glands and oviducts. In immature individual the ovary is barely discernible and it contains no eggs; the shell gland is also very small and the oviducts are thick-walled and white. In maturing individual white eggs are visible in the ovary but the remainder of the reproductive system is similar to that of immature individual. In mature individual the ovary contain yellow eggs, the shell gland is enlarged and the oviducts distended.

All the information, relative to the 10,358 specimens, was coded and filed in a data base in an IBM computer.

RESULTS

Distribution of the stock

Galeus melastomus was caught, during the periods of study, within the whole area of the Ionian Sea. However, its presence was found to be limited to the bathyal depths and, in particular, from 200 m down to the maximum depth explored (650 m) (Table I). The specimens found in the epibathyal depths (200-400 m) were almost exclusively small (70-280 mm) and mainly concentrated at around 300 m, while in the mesobathyal (400-650 m) the population was found to be made up of all classes of length (70-550 mm), including a considerable number of recruits. The stock was only found at depths greater than 400 m during August and September-October 1986. No significant differences between the sexes were detected as far as the bathymetric distribution of the species was concerned (Table II).

Table I. - Average number of individuals per hour (N° ind./h) with standard deviation, related to depth strata and number of hauls, of *Galeus melastomus* caught in the Ionian Sea during the trawl surveys carried out from 1985 to 1989.

Cruises	Depth (m)			
	200-400		400-650	
	N° hauls	N° ind./h (average ± s. d.)	N° hauls	N° ind./h (average ± s. d)
April-May 1985	14	55.4 ± 101.6	7	261.9 ± 274.5
Sept.-Oct. 1985	10	7.6 ± 19.4	9	157.2 ± 209.8
April-May 1986	11	10.6 ± 31.8	9	21.3 ± 27.7
Sept.-Oct. 1986	10	0,0 ± 0,0	8	154.9 ± 130.7
April-May 1987	8	63 ± 130.5	10	60 ± 68.3
Oct.-Nov. 1988	10	123.6 ± 251.2	8	143.3 ± 107.9
June 1989	9	64.8 ± 141.26	8	102.2 ± 121.8

In the context of the seven trawl surveys statistically significant differences were found between the average number of individuals per hour caught in each stratum ($t = 3.09$, $df = 129$, $p < 0.002$).

Table II. - Average length (mm) with standard deviation and number of individuals for females and males, related to depth strata, of *Galeus melastomus* caught in the Ionian Sea during 1985-1989.

Cruises	**Sex**	**Depth (m)**			
		200-400		**400-650**	
		N° ind.	**Length (mm)**	**N° ind.**	**Length (mm)**
April-May 1985	Females	362	208 ± 83	202	239 ± 94
	Males	326	200 ± 65	232	245 ± 85
Sept-Oct 1985	Females	33	251 ± 54	691	214 ± 82
	Males	38	262 ± 59	730	208 ± 74
February 1986	Females	23	212 ± 21	121	215 ± 27
	Males	25	215 ± 27	90	266 ± 102
March 1986	Females	95	185 ± 66	134	224 ± 105
	Males	93	175 ± 26	132	211 ± 102
April-May 1986	Females	125	191 ± 43	175	216 ± 82
	Males	136	180 ± 39	150	197 ± 46
August 1986	Females	-	-	246	195 ± 47
	Males	-	-	342	197 ± 53
Sept-Oct 1986	Females	-	-	525	238 ± 65
	Males	-	-	625	228 ± 61
April-May 1987	Females	261	205 ± 36	308	274 ± 72
	Males	310	207 ± 39	292	283 ± 76
Oct-Nov 1988	Females	589	204 ± 71	488	318 ± 102
	Males	674	196 ± 65	595	320 ± 83
June 1989	Females	198	190 ± 49	388	262 ± 100
	Males	195	184 ± 42	409	278 ± 98

Structure of the population

The structuring of the population into classes of length derives from analysis of the composition of the catches, since only individuals of very small size (pre-recruits) are able to escape through the meshes of the net.

The population of *Galeus melastomus* in the Ionian Sea is made up mostly of young specimens, smaller than 250 mm in total length (on average 70.8%). In every period and for the entire area, the length-frequency distribution is plurimodal, with a wide range between the minimum and the maximum observed (average range = 460 mm) (Fig. 2). The average length for females and males related to the depth strata is presented in table II.

As previously stated, while specimens of small size are found at every depth, those of larger dimensions tend to be distributed at a depth greater than 400 m.

In the mesobathyal (400-650 m) all sizes are represented in the population and almost always make up a polygon of frequency with more modal peaks in which the most numerous are represented by the specimens of small size. A highly significant difference was noted between the size frequencies observed in the epibathyal and those found in the mesobathyial ($\chi^2 = 36.73$, d.f. = 2, $p < 0.001$). However, in the first stratum the minimum and maximum lengths observed were, respectively, 75 mm and 550 mm in the female and 70 mm and 510 mm in the male; whereas in the second, they were, respectively, 90 mm and 550 mm in the female and 70 mm and 500 mm in the male.

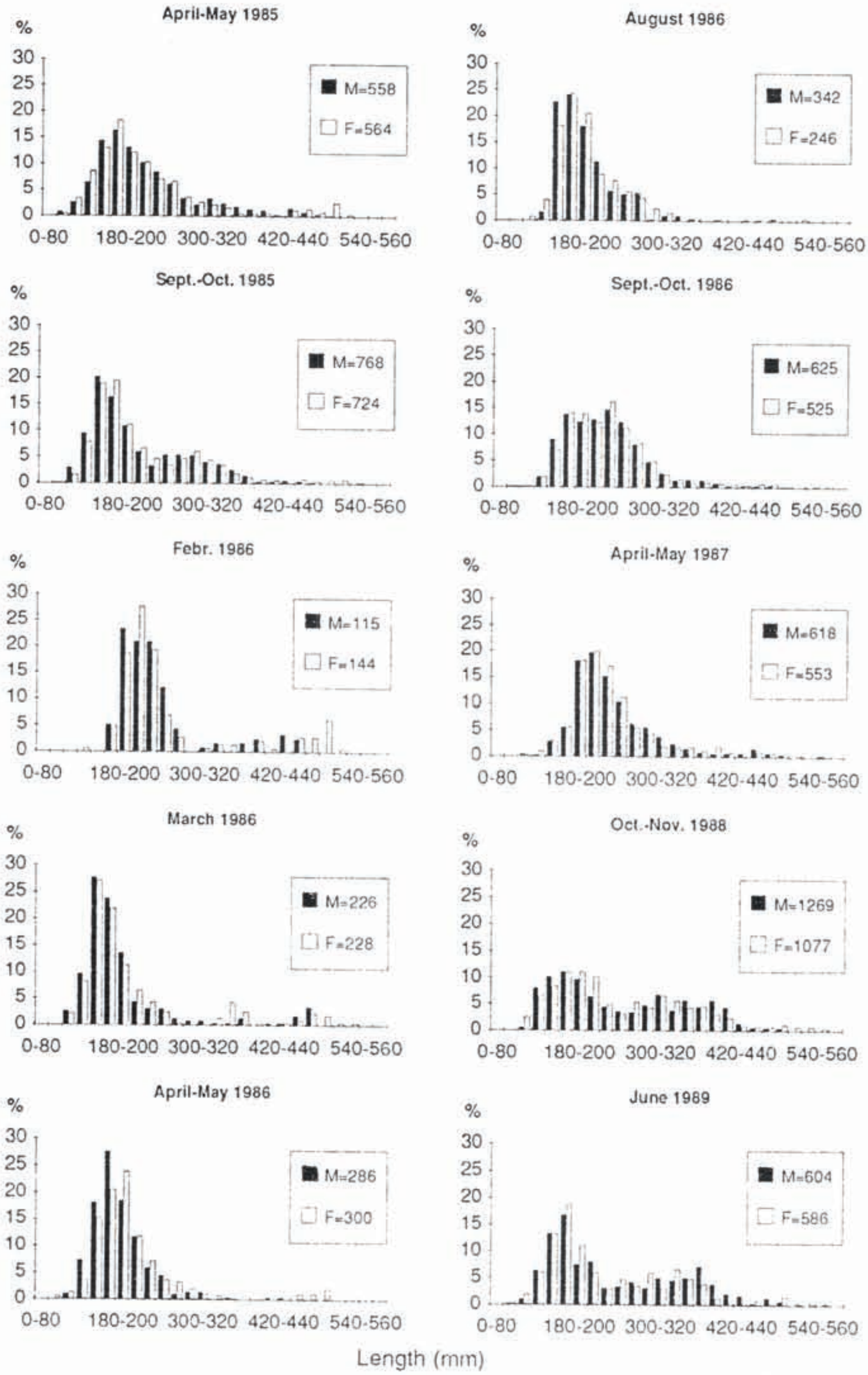

Fig. 2. - Length-frequency distribution of *Galeus melastomus* caught in the Ionian Sea during 1985-1989.

During the trawl survey carried out in October-November 1988, shortly after the closed season, the stock showed a change in distribution towards sizes 250 mm larger than in the previous surveys. In fact, the different composition for classes of length between the population sampled during the aforementioned survey and that of the previous one, was highly statistically significant ($\chi^2 = 30.71$, d.f. = 2, $p < 0.001$).

The recruitment of the population sampled was observed during every survey, except that in February. The recruits, as previously mentioned, were located both in the epibathyal and mesobathyal without showing any particular geographic areas of concentration that could be interpreted as nurseries. In fact, even though the Ionian is geomorphologically divided from the Bradanic pit in an eastward slope and in a southwestward slope, small individuals are found abundantly in both areas.

The sex ratio was almost 1:1 both in the stock as a whole and in that at the two depth strata in which the species was found. In the mesobathyal, the relationship between the sexes was slightly in favour of the female (1.3:1) only in February of 1986, while a slight prevalence of males was found in August (1:1.4) and September-October (1:1.2) of the same year and again in October-November of 1988 (1:1.2). The aforementioned relationship of 1:1 was generally found even in single catches.

Biometry and growth

Although in the population examined in the several periods and for the different depths the average size of the two sexes was found to be fairly similar, in the Ionian Sea the largest females measured 550 mm and the males 500 mm in total length.

The data used for the length-weight analysis ($W = a \cdot L^b$, where W is the total weight in grammes, L is the total length in millimeters, a and b are constants) were collected from 556 females and 604 males caught during the last survey (June 1989). The regression employed on the data available reveals the following size-weight relationship for each sex:

Females: $W = 25.7 \cdot 10^{-3} \cdot L^{3.05}$ $r = 0.985$
Males: $W = 30.5 \cdot 10^{-3} \cdot L^{2.99}$ $r = 0.985$

On the basis of these relationships, it is shown that the females tend to be slightly heavier than males of equal length and that, for both of the sexes, the function of regression reveals, in agreement with what is known, the isometric growth of the individuals.

Despite the superposition of the cohorts owing to the continuous reproductive period of *Galeus melastomus* during the year (Capapé and Zaouali, 1977), and seen in the length-frequency distribution, some modal peaks allowed the estimation of the growth in the first phases of life on the basis of their progression over time (Pauly, 1983; Cailliet, 1990). In particular, with regard to the females, whose sizes were found to be distributed among the modal peak of 150-160 mm in March 1986, sizes of approximately 180 mm in April-May and 240 mm in September-October of the same year; males which in March measured 150-160 mm, reached lengths of 170-180 mm in April-May and 230 mm at the beginning of autumn. This rate of growth (little more than 10 mm/month), can be supported by the fact that for females the modal peak of 160-170 mm found in the population sampled in August 1986 became 170-180 mm in September-October, while for males the modal component of 150-160 mm from those sampled in August progressed to 160-170 mm in the following September-October (Fig. 3).

Reproduction

It was observed that the population of *Galeus melastomus* is mostly represented by individuals in pre-reproductive phase: however, individuals with mature gonads were found in every period, mainly at the lowest depths (Table III).

The smallest mature female was 410 mm and the smallest mature males 340 mm. The size at first maturation (the size at which 50 percent of individuals are mature) was 490 mm and 450 mm in the females and males respectively.

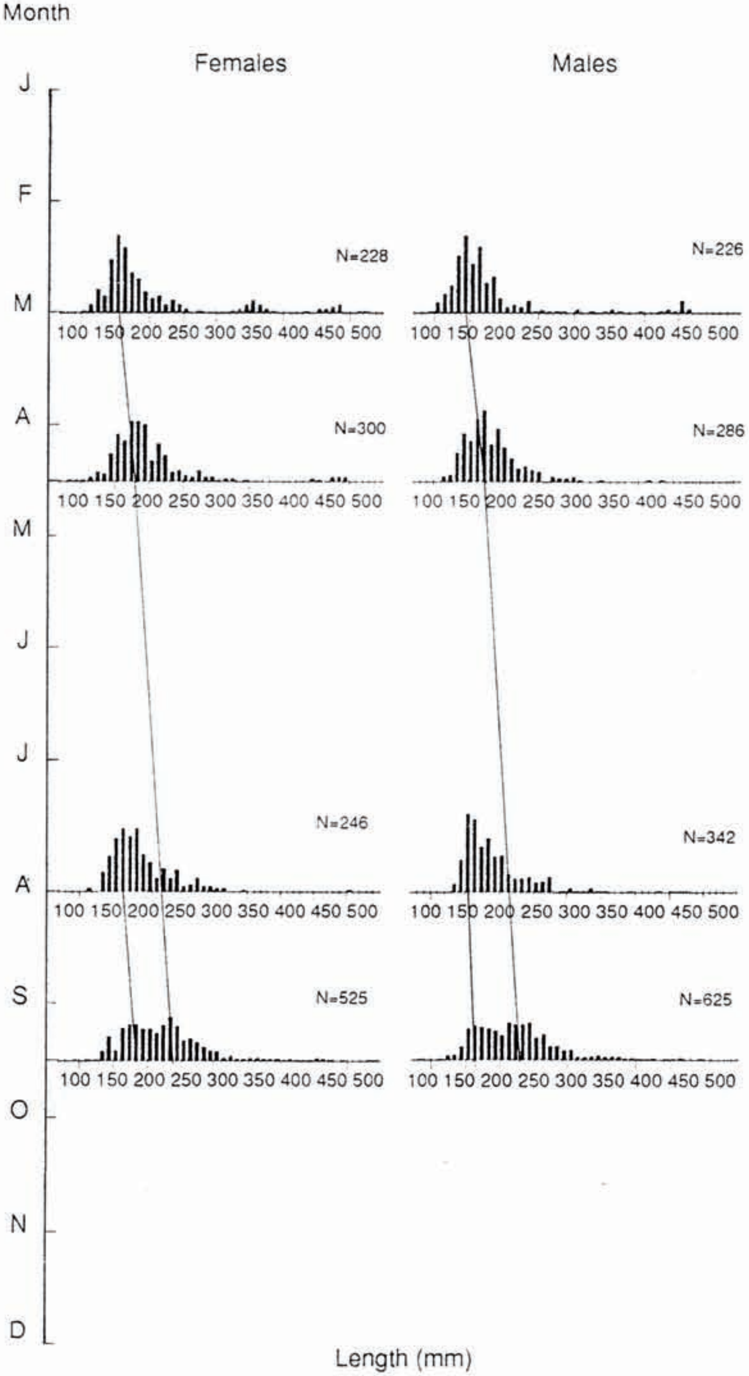

Fig. 3. - Trend of growth of *Galeus melastomus* caught in the lonian Sea from March to September-October 1986.

Table III. - Maturity stage, related to depth strata, of the individuals of *Galeus melastomus* caught in the Ionian Sea during 1985-1989.

Depth			Apr.-May 1985	Sept.-Oct. 1985	Febr. 1986	March 1986	Apr.-May 1986
200 to 400 (m)	Males	Immature	99 %	97 %	100 %	100 %	100 %
		Maturing	-	-	-	-	-
		Mature	1 %	3 %	-	-	-
	Females	Immature	95 %	100 %	39 %	98 %	44 %
		Maturing	-	-	61 %	-	66 %
		Mature	5 %	-	-	2 %	-
400 to 650 (m)	Males	Immature	100 %	97 %	96 %	90 %	99 %
		Maturing	-	-	-	-	-
		Mature	-	3 %	4 %	10 %	1 %
	Females	Immature	92 %	97 %	52 %	93 %	38 %
		Maturing	-	-	32 %	4 %	55 %
		Mature	8 %	3 %	16 %	3 %	7 %
Depth			**Aug. 1986**	**Sept.-Oct. 1986**	**Apr.-May 1987**	**Oct.-Nov. 1988**	**June 1989**
200 to 400 (m)	Males	Immature	-	-	100 %	96 %	87 %
		Maturing	-	-	-	3 %	13 %
		Mature	-	-	-	1 %	-
	Females	Immature	-	-	53 %	86 %	83 %
		Maturing	-	-	47 %	13 %	16 %
		Mature	-	-	-	1 %	1 %
400 to 650 (m)	Males	Immature	96 %	97 %	66 %	57 %	71 %
		Maturing	2 %	1 %	23 %	27 %	20 %
		Mature	2 %	2 %	11 %	16 %	9 %
	Females	Immature	27 %	12 %	13 %	34 %	59 %
		Maturing	73 %	86 %	84 %	60 %	37 %
		Mature	-	2 %	3 %	6 %	4 %

Vitellogenesis was observed in every period of the study and the females with mature gonads presented eggs containing yolks of various dimensions, up to as large as 16 mm in diameter. In one female of 550 mm TL, 23 eggs of 13 mm were counted together with numerous others of smaller dimensions. Generally, the number of eggs carrying yolk was approximately a dozen, and those present in the oviducts enveloped in capsules amounted to one or two on each side. Exceptionally, in the autumn of 1988, at a depth of 600 m, a female of 500 mm was caught with 8 eggs of 13-14 mm in diameter and 8 ovigerous capsules in the oviducts, 4 on each side. In the same period, at 500 m, an individual of 485 mm with 10 eggs and 3 capsules in each oviduct was found. Occasionally, at the lower depths, one or two capsules were found in the catch outside the actual specimens, which could have been the result of violent expulsion generated by the trauma of being caught.

The dimensions of the capsules estimated during the whole period of study ranged from a minimum of 45 x 17 mm to a maximum of 55 x 20 mm.

DISCUSSION AND CONCLUSIONS

Galeus melastomus in the Ionian Sea is found exclusively in the bathyal depths. The almost exclusive presence of young individuals in the epibathyal confirms what has been documented in the literature (Capapé and Zaouali, 1977; Relini Orsi and Wurtz, 1975, 1977; Relini Orsi *et al.*, 1982; Muñoz-Chápuli, 1984). A large part of the population, including the more mature individuals, is located in the mesobathyal, without showing significant seasonal fluctuations in its dimensions or composition for length classes and, therefore, of age. The Ionian population of *Galeus melastomus* was found to consist mostly of young individuals, which could be attributed mainly to the overfishing carried out at the bathyal depths, aimed at the catching of valuable species such as *Aristeus antennatus*, *Nephrops norvegicus* and *Merluccius merluccius*. Although variation in the ratio of the length classes (and those of age) depends, as is known, on fluctuation in the recruitment and on the success of the various generations, the different composition of size groups found in October-November of 1988 could be a consequence of the "closed season" for fishing from 1st September to 15th October of the same year.

The schools of the species in the bathyal environment investigated are made up of females and males in equal measure, according to Capapé and Zaouali (1977). The females are slightly bigger than the males, and the maximum sizes observed fall in with the typical dimensions of the Mediterranean species, even if they are a little smaller than those found in Tunisia (Capapé and Ben Brahim, 1984).

At hatching the individuals of *Galeus melastomus* measure about 70 mm and in the initial phases of life the rate of growth is quite rapid. In relation to what has been previously stated regarding growth, it can be seen that the individuals of both sexes that make up the first modal peak belong to the age group 0+ while those of the larger size of 220-230 mm are in their second year (1+). Furthermore, considering that the increase in the length of a fish is asymptotic with respect to time (Gulland, 1969) (i.e., the rate of growth reduces as the age of the individual increases), it can be deduced that in order to reach the maximum dimensions observed, in both sexes, at least 7-8 years of life would be necessary. On the basis of this growth rate sexual maturity in *Galeus melastomus* would be reached around the third or fourth year of life, in agreement with what is known about the populations composed of numerous age groups (Nikolsky, 1963) and the fact that sharks generally mature late in life (Pratt and Casey, 1990).

The superposition of the cohorts shown in the length-frequency distribution, the fairly continuous recruitment, as well as the maturative stages of the gonads and the products of reproduction found in the population in every period of the study, demonstrate that, also in the Ionian Sea, the reproduction of *Galeus melastomus* occurs continuously throughout the year (Lo Bianco, 1909; Wheeler, 1969; Capapé and Zaouali, 1977).

Some other aspects, such as the presence of recruits both between 200 and 400 m and between 400 and 650 m, a greater percentage of mature individuals in the mesobathyal than in the epibathyal and the homoeothermic condition in the bathyal environment of Mediterranean, indicate, in our opinion, that the reproduction occurs at the lowest depths at which the species is found. In the first years of life, *Galeus melastomus* is distributed on a wide bathymetric bathyal slope, probably because of the different feeding requirements of the young compared to those of the adult (Relini Orsi and Wurtz, 1977) and, successively, it moves to the lower depths investigated, reproducing and concluding its life cycle. Although any segregation of the sexes in the Ionian Sea has not been observed, this pattern of vertical distribution is similar to that proposed by Bullis (1967) for *Galeus arae*.

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